Special Report
Geophysical Activity in 1979

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INTRODUCTION

This report presents statistical data on geophysical activity in 1979. The data were compiled from survey questionnaires that were completed by more than 500 companies, contractors, government agencies, and institutions throughout the free world. We have gathered information from users of geophysical techniques in the areas of petroleum, mining, geothermal, and groundwater exploration; and from those who employ geophysical methods in engineering surveys, oceanography, and research. Data were gathered on airborne, drill hole, land, and marine geophysical surveys. Statistics were compiled on miles of coverage, drill hole footage, time spent in crew months or man months, and acquisition cost.

Two questionnaires were sent to all recipients. One was the original form which was designed primarily for reporting petroleum activities. An alternate questionnaire was designed to facilitate reporting of nonpetroleum geophysical activities. New computer software was developed to handle data reported on the alternate questionnaire. Data not supplied on the questionnaires by the respondent were estimated on the basis of massive statistical averaging for the area and techniques reported. This process is necessary to avoid distortion of individual statistical items.

Data reported here, when compared to past annual reports, provides a basis for detecting and analyzing trends in technological developments and exploratory trends in geographical areas. Changes in these trends reflect the influence of many factors, such as technological advances, inflation, government regulations, and exploration philosophy. Cost figures are sensitive to many factors, such as operational environment, length and nature of the survey, type of instrumentation, etc. Unit costs reported by universities are substantially lower than those reported by industry due to the use of student labor and donated equipment. These costs,

Table 1. Total worldwide expenditures in U.S. $ (thousands) by survey type and objective.

Type	Petroleum[1]	Minerals	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
Land	1,390,644	13,458	6,370	2,656	4,906		2,765	1,420,799
Marine	551,604	4	12,405			23,479	2,414	589,906
Airborne	12,283	25,520	806	156		300	715	39,780
Drill Hole	558	5,391	2,499	2,084	486		65	11,083
Total	1,955,084	44,375	22,081	4,896	5,392	23,779	5,959	2,061,566

[1]Includes processing and interpretation costs for land and marine. See text for details.

Note: All tables in this report where figures are expressed in thousands of dollars have been rounded off as individual items; but the computer keeps track of the truncated numbers and then the sums of the individual items are rounded off. As a result of this procedure, the rounded individual items will not add up precisely to the rounded sums.

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Report of the SEG Geophysical Activity Committee. The members of the Committee are Carlos Aiken, W. E. Blakely, T. L. Dobecki, Lin Evans, D. A. Fahlquist, O. E. Gregson, R. R. Hartman, David Hastings, R. J. Jones, F. P. Kronberger, David Langenkamp, R. S. Middleton, J. Roth, T. R. Salisbury, R. J. Senti, and M. G. Whitmire, Chairman.

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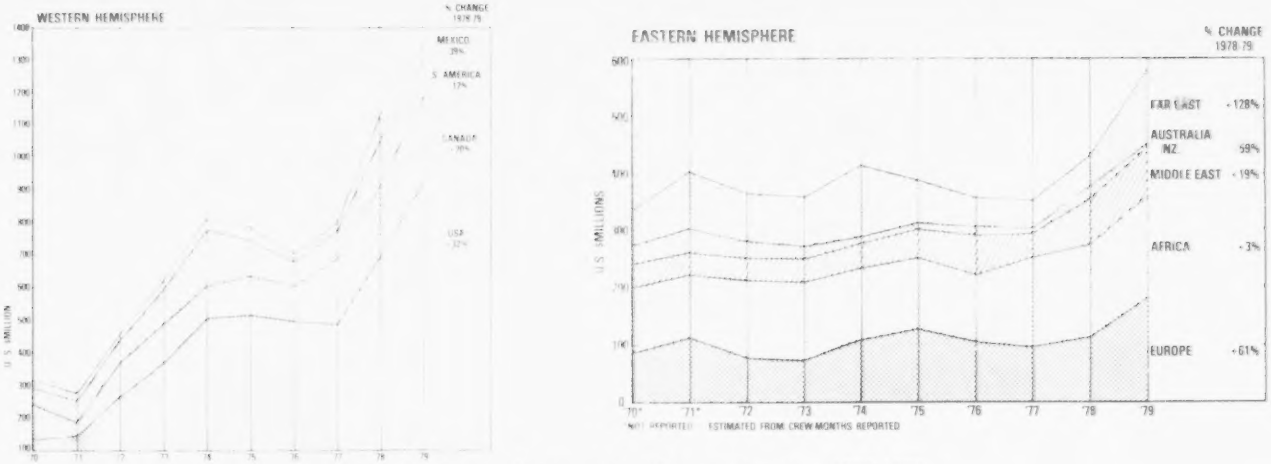

FIG. 1. Total expenditures on petroleum exploration, 1970-1979.

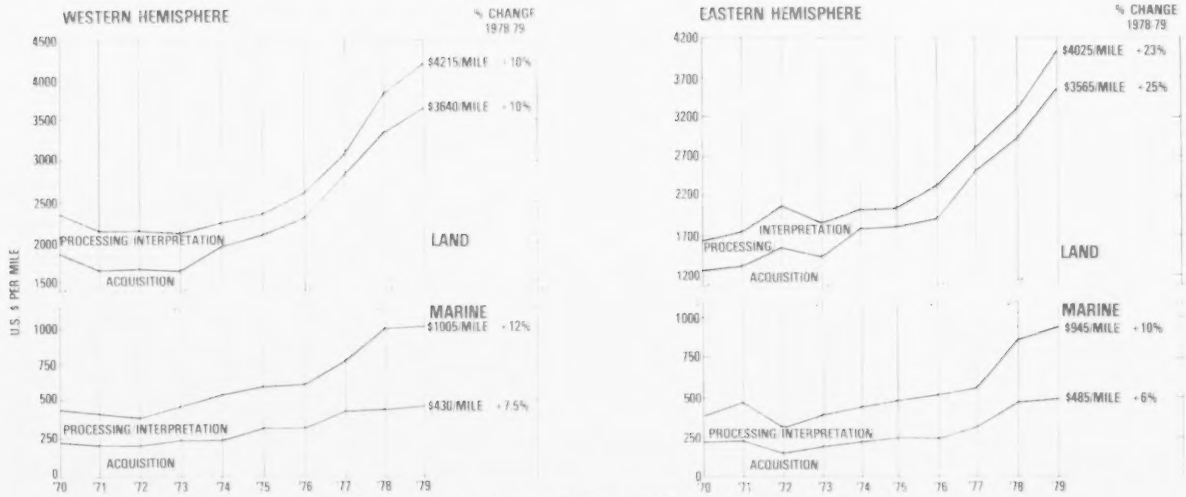

FIG. 2. Average cost per mile for petroleum surveys, 1970-1979.

Table 2. Total worldwide expenditures in US $ (thousands) by area and survey objective.

Area	Petroleum[1]	Minerals	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
International	20,844		500			4,485	1,860	27,689
U.S.A.	917,599	11,266	9,571	3,641	550	1,359	2,419	946,405
Canada	257,928	13,645	384				588	272,545
Mexico‡	52,249	100	30					52,379
So. America	122,940	334	1,244		279	817	331	125,945
Europe	182,181	8,376	4,569	105	407	828	25	196,491
Africa	179,132	4,914	3,443	1,000	4,035	86	310	192,920
Middle East	86,790	2,401	73		36			89,300
Far East	128,671	1,688	2,265	175	83	16,201	349	149,432
Australia/ New Zealand	6,750	1,647					75	8,472
Total	1,955,084	44,375	22,081	4,921	5,392	23,779	5,959	2,061,566

[1]Includes processing and interpretation costs. ‡Incomplete report.

however, must be averaged with industry costs to accommodate the format of the report. Therefore, when examining unit cost figures, one must be cognizant of the broad spectrum of activity embraced by individual categories.

1979 HIGHLIGHTS

Record inflation and higher oil prices brought another sharp increase in geophysical expenditures in 1979. Worldwide expenditures for geophysical exploration were up 23 percent, rising above the US $2 billion mark (see Table 1). Expenditures reported for engineering work showed the greatest increase, rising 148 percent. Geothermal expenditures were up 130 percent, oceanography up 72 percent, groundwater up 65 percent, and mining increased 40 percent. Expenditures for petroleum activities were up 22 percent. The increases reported in nonpetroleum activities are due in part to the new alternate questionnaire which was adopted to encourage reporting from this segment of the geophysical community. It also reflects the underreported condition in prior years. We suspect that these areas of activity are still underreported by a substantial margin.

Approximately 46 per cent of all expenditures for geophysical work was spent in the U.S.A., an increase of 3 percent over 1978 (see Table 2). Geophysical expenditures in the U.S.A. increased 30 percent over 1978. Canada showed an increase of 22 percent, South America was down slightly, Europe showed a healthy increase, Africa and the Middle East showed a slight increase. The Far East showed an increase of 157 percent due to the heavy activity offshore China.

The cost of processing and interpretation are included in Tables 1 and 2 and Figures 1 and 2, but all other tables show acquisition costs only. Since we do not receive information on processing and interpretation costs, these figures must be estimated. US $575 per line-mile was used for the Western Hemisphere and US $460 per line-mile was used for the Eastern Hemisphere. The higher cost in the Western Hemisphere is based on the premise that, in general, a more rigorous processing and interpretation treatment is required because of the subtle structural and stratigraphic prospects that may be economically viable objectives in much of the Western Hemisphere but are not usually primary targets in much of the Eastern Hemisphere. These cost estimates were increased over 1978 because of the effects of inflation and the strong movements toward "seis-strat" exploration and the "people and processing" intensive nature of this technology.

Table 3. Worldwide petroleum land seismic activity.

Area	Acquisition costs (US $)	Line-miles	Crew-months* Company	Contract	Crew-months total*	Average mile/ month	Average cost/ month	Average cost/ mile
U.S.A.	623,826,007	163,929	758.4	3,364.0	4,122.4	39	151,325	3,805
Canada	201,859,865	57,375	100.5	616.5	717.0	80	281,533	3,518
Mexico‡	9,925,530	3,532		74.6	74.6	47	133,050	2,810
So. America	49,977,509	18,304		275.5	275.5	66	181,406	2,730
Europe	84,271,708	28,192		502.9	502.9	56	167,571	2,989
Africa	127,739,222	28,186	1.0	579.6	580.6	48	220,012	4,532
Middle East	73,618,188	21,586		330.3	330.3	65	222,882	3,410
Far East	37,080,162	12,546		249.3	249.3	50	148,737	2,955
Australia/ New Zealand	0	0						
Total	1,208,298,191	333,650	859.9	5,992.7	6,852.6	48	176,326	3,621

*Total includes government and university activity. ‡Incomplete report.

Table 4. Petroleum land seismic line-miles by energy source.

Area	Dynamite	Compressed air	Electrical	Gas exploder	Implosive	Weight drop	Solid chemical	Vibrator	Other	Total Line-miles
U.S.A.	82,849	9,347	82	3,056	17		1,069	67,226	285	163,929
Canada	49,827							7,548		57,375
Mexico‡	324							3,208		3,532
So. America	6,880						180	11,120	124	18,304
Europe	12,911							14,517	763	28,192
Africa	15,996					3,586		6,646	994	28,186
Middle East	7,607					2,012		13,907		21,586
Far East	10,209							294	2,043	12,546
Australia/ New Zealand										0
Total	185,623	9,347	82	3,056	17	5,598	1,249	124,466	4,209	333,650

‡Incomplete report.

Table 5. Petroleum marine seismic activity.

Area	Acquisition costs (U.S.$)	Line-miles	Crew-months* Company	Crew-months* Contract	Crew-months total*	Average mile/month	Average cost/month	Average cost/mile
International	19,253,829	33,261		40.7	40.7	817	473,067	578
U.S.A.	76,538,355	193,242	70.6	207.3	277.9	695	275,416	396
Canada	14,230,155	14,592	6.6	18.4	25.0	583	569,206	975
Mexico‡	18,460,488	35,536		34.7	34.7	1,024	532,000	519
So. America	23,455,156	63,446	7.2	56.8	64.0	1,021	366,486	358
Europe	41,565,528	90,658	3.7	97.0	98.7	917	421,332	459
Africa	17,897,877	37,493	2.5	35.2	37.7	992	474,744	478
Middle East	1,019,600	3,532		2.1	2.1	1,681	485,523	288
Far East	45,236,496	83,195	5.2	84.4	89.6	928	504,871	543
Australia/ New Zealand	2,610,880	9,006		9.0	9.0	1,000	290,000	290
Total	260,287,390	565,725	93.8	585.6	679.4	832	383,113	460

*Total includes government and university activity. ‡Incomplete report.

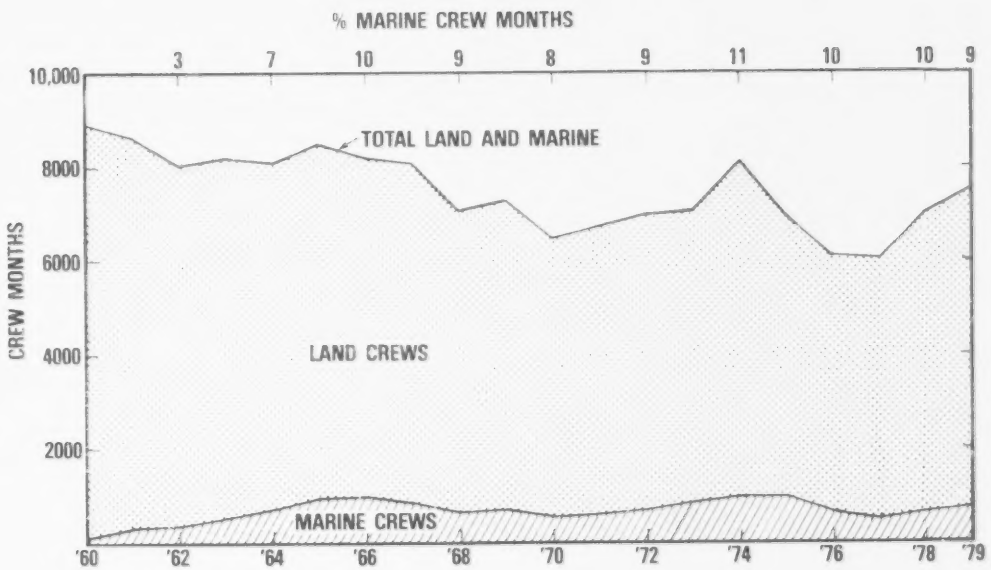

FIG. 3. Worldwide seismic activity in crew-months, 1960-1979.

Table 6. Petroleum marine seismic line-miles by energy source.*

Area	Compressed air	Electrical	Gas exploder	Implosive	Solid chemical	Total line-miles
International	33,261					33,261
U.S.A.	117,612	2,400	70,200		3,000	193,212
Canada	8,364		6,228			14,592
Mexico‡	30,044			5,492		35,536
So. America	42,255		21,800	1,351		65,406
Europe	35,170		34,700	18,715	2,000	90,585
Africa	13,693		5,900	6,313	11,500	37,406
Middle East	3,386			146		3,532
Far East	56,195		27,000			83,195
Australia/ New Zealand	9,000					9,000
Total	348,980	2,400	165,828	32,017	16,500	565,725

*No reports received for dynamite, weight drop, or vibrator energy sources. ‡Incomplete report.

PETROLEUM EXPLORATION

Almost 95 percent of all geophysical dollars are spent on the search for petroleum. Over US $1.95 billion was spent on petroleum exploration in 1979. Expenditures in the U.S.A. increased 32 percent, while Canada increased 20 percent. The Far East showed the greatest increase, 128 percent, again due to the increased work offshore China. Geophysical activity in the Western Hemisphere increased 19 percent while the Eastern Hemisphere increased 35 percent.

A 10-year history of geophysical activity in both the Western and Eastern Hemispheres is shown in Figure 1.

SEISMIC SURVEYS

The seismic method accounted for over 92 percent of all geophysical expenditures in 1979. This statistic, plus the strong tendency for wildcat activity to tract seismic activity (with a 1 to 2 year lag), has caused those interested in forecasts of petroleum exploration to regard seismic activity as the best barometer. A 10-year history of the costs of petroleum seismic surveys in both the Western and Eastern Hemispheres is shown in Figure 2. In the Western Hemisphere, the acquisition costs per mile for land seismic surveys was up 10 percent, while marine costs rose 7.5 percent. In the Eastern Hemisphere,

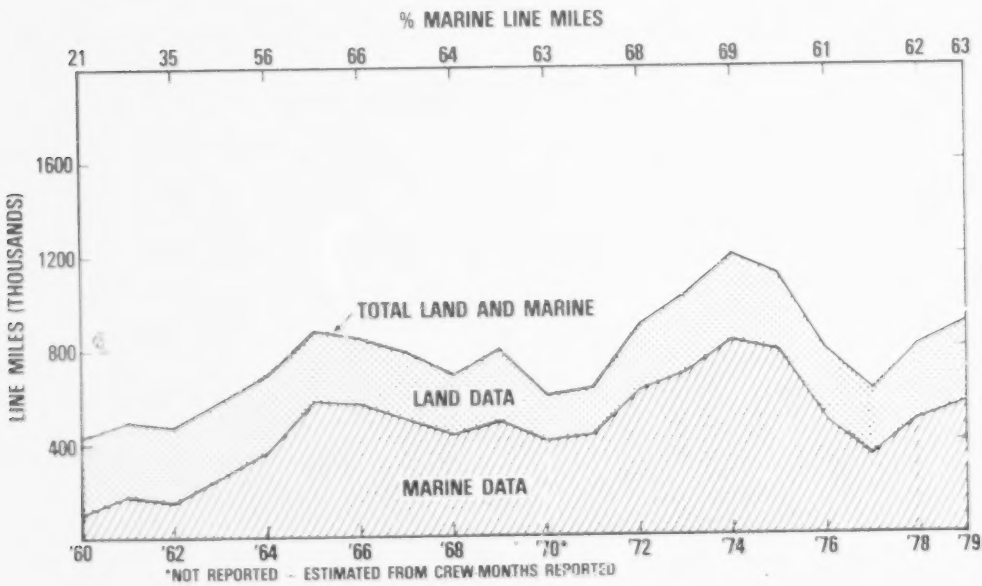
% MARINE LINE MILES
21 35 56 66 64 63 68 69 61 62 63
LINE MILES (THOUSANDS)
1600
1200
800
400
TOTAL LAND AND MARINE
LAND DATA
MARINE DATA
'60 '62 '64 '66 '68 '70* '72 '74 '76 '78 '79
*NOT REPORTED - ESTIMATED FROM CREW MONTHS REPORTED

FIG. 4. Worldwide seismic activity in line-miles, 1960-1979.

Table 7. Worldwide average unit costs for petroleum surveys.

Area, survey type and method	Crew-months total*	Line miles	Acquisition costs (U.S.$)	Average mile/month	Average cost/month	Average cost/mile
International						
Marine						
Seismic comp. air	40.7	33,261	19,253,829	817	473,067	578
Airborne						
Magnetic	6.0	40,000	990,500	6,666	165,083	24
R/S side-scan radar	6.0	40,000	600,000	6,666	100,000	15
U.S.A.						
Land						
Seismic dynamite	2,502.4	82,849	389,995,489	33	155,848	4,707
Seismic comp. air	92.9	9,333	15,212,064	100	163,746	1,628
Seismic electrical	1.0	84	210,000	84	210,000	2,500
Seismic gas exploder	71.8	3,056	7,987,236	42	111,242	2,613
Seismic implosive	1.0	17	178,703	17	178,703	10,511
Seismic solid chem.	39.7	1,066	7,035,880	26	177,226	6,581
Seismic vibratory	1,404.1	67,226	201,790,635	47	143,715	3,001
Seismic other	10.0	285	1,416,000	26	141,600	4,968
Gravity	110.8	28,968	2,323,412	261	20,969	80
Magnetic	4.7	250	27,865	53	5,928	111
Resistivity	0.5	10	20,000	20	40,000	2,000
Induced polarization	5.0	500	175,000	100	35,000	350
Radiometric (gamma ray)	6.0	1,300	860,000	216	143,333	661
Magnetotelluric	30.0	336	2,368,000	11	78,933	7,047
Other	4.0	76	309,000	19	77,250	3,911
Marine						
Seismic comp. air	197.8	117,539	51,151,862	594	258,603	435
Seismic comp. air (refrac.)	.5	73	216,861	146	433,722	2,970
Seismic electrical	4.0	2,400	1,072,000	600	268,000	446
Seismic gas exploder	72.6	70,200	23,212,632	966	319,733	330
Seismic solid chem.	3.0	3,000	885,000	1,000	295,000	295
Airborne						
Magnetic	29.8	158,600	3,809,700	5,322	127,842	24
R/S side-scan radar	1.5	99,999	1,800,000	66,666	1,200,000	18
Drill hole						
Sonic vel. logging	6.3	**	186,437	**	29,593	**
Canada						
Land						
Seismic dynamite	597.9	49,647	178,737,612	83	298,942	3,600
Seismic dynamite (refrac.)	3.0	180	97,000	60	32,333	538
Seismic vibratory	116.1	7,548	23,025,253	65	198,322	3,050
Gravity	4.0	800	68,000	200	17,000	85
Induced polarization	12.0	1,200	250,000	100	20,833	208
Marine						
Seismic comp. air	9.4	8,364	11,942,884	889	1,270,519	1,427
Seismic gas exploder	15.6	6,228	2,287,271	399	146,619	367
Gravity	2.8	4,446	111,885	1,587	39,958	25
Magnetic	0.2	1,110	27,753	5,550	138,765	25
Mexico‡						
Land						
Seismic dynamite	9.6	324	1,330,530	33	138,596	4,106
Seismic vibratory	65.0	3,208	8,595,000	49	132,230	2,679
Marine						
Seismic comp. air	27.8	30,048	15,714,400	1,080	565,266	523
Seismic implosive	6.9	5,492	2,746,000	795	397,971	500
Airborne						
Magnetic	16.0	58,500	1,400,000	3,656	87,500	23

*Total includes government and university activity. **Not applicable. ‡Incomplete report.

Table 7. Worldwide average unit costs for petroleum surveys (cont.)

Area, survey type and method	Crew-months total*	Line miles	Acquisition costs (U.S.$)	Average mile/month	Average cost/month	Average cost/mile
So. America						
Land						
Seismic dynamite	127.8	6,880	22,781,826	53	178,261	3,311
Seismic solid chem.	3.0	180	516,000	60	172,000	2,866
Seismic vibratory	142.0	11,320	26,342,232	78	185,508	2,368
Seismic other	2.7	124	337,451	45	124,981	2,721
Gravity	5.0	1,940	118,541	388	23,708	61
Magnetotelluric	3.0	45	450,000	15	150,000	10,000
Marine						
Seismic comp. air	40.1	42,255	15,732,160	1,053	392,323	372
Seismic gas exploder	22.2	21,800	7,047,496	981	317,454	323
Seismic implosive	1.7	1,351	675,500	794	397,352	500
Gravity	6.7	11,997	251,010	1,790	37,464	20
Magnetic	0.1	123	3,083	1,230	30,830	25
Airborne						
Magnetic	1.4	13,100	500,000	9,357	357,142	38
Drill hole						
Sonic/vel. logging	3.5	**	52,500	**	15,000	**
Europe						
Land						
Seismic dynamite	260.0	12,912	45,298,200	49	174,223	3,508
Seismic vibratory	227.0	14,517	37,186,150	63	163,815	2,561
Seismic other	15.9	763	1,787,358	47	112,412	2,342
Magnetic	24.0	6,450	597,816	268	24,909	92
Resistivity	1.0	15	66,000	15	66,000	4,400
Combined EM/Mag.	8.5	579	237,260	68	27,912	409
Marine						
Seismic comp. air	38.1	35,170	20,758,500	923	544,842	590
Seismic gas exploder	35.2	34,700	10,889,528	985	309,361	313
Seismic implosive	23.4	18,715	9,357,500	799	399,893	500
Seismic solid chem.	2.0	2,000	580,000	1,000	290,000	290
Gravity	2.5	3,108	45,000	1,243	18,000	14
Airborne						
Magnetic	3.6	28,130	462,141	7,813	128,372	16
Drill hole						
Sonic/vel. logging	6.0	**	90,000	**	15,000	**
Sonic/vel. logging	(35.8)	(93,000)	187,878	(2,598)	5,248	(2.02)
	(man months)	(ft)		(ft/man-month)		(cost/ft)
Africa						
Land						
Seismic dynamite	329.0	16,960	91,660,655	51	278,603	5,404
Seismic weight drop	70.4	3,586	6,958,715	50	98,845	1,940
Seismic vibratory	161.0	6,646	27,002,422	41	167,716	4,062
Seismic other	20.2	994	2,117,430	49	104,823	2,130
Gravity	27.0	7,492	2,293,205	277	84,933	306
Electromagnetic	8.0	545	223,300	68	27,912	409
Marine						
Seismic comp. air	12.1	13,693	8,761,660	1,131	724,104	639
Seismic gas exploder	6.0	5,900	2,644,711	983	440,785	448
Seismic implosive	8.1	6,313	3,156,500	779	389,691	500
Seismic solid chem.	11.5	11,500	3,335,000	1,000	290,000	290
Gravity	2.0	3,159	72,230	1,579	36,115	22
Magnetic	0.1	262	6,538	2,620	65,380	24
Airborne						
Magnetic	3.9	32,061	503,527	8,220	129,109	15
Drill hole						
Sonic/vel. logging	15.0	**	225,000	**	15,000	**
Australia/New Zealand						
Marine						
Seismic comp. air	9.0	9,000	2,610,000	1,000	290,000	290

*Total includes government and university activity. **Not applicable. ‡Incomplete report.

Table 7. Worldwide average unit costs for petroleum surveys (cont.).

Area, survey type and method	Crew-months total*	Line-miles	Acquisition costs (US $)	Average mile/month	Average cost/month	Average cost/mile
Middle East						
Land						
Seismic dynamite	104.7	5,667	27,125,026	54	259,073	4,786
Seismic weight drop	36.0	2,012	3,455,481	55	95,985	1,717
Seismic vibratory	189.6	13,907	43,037,681	73	226,991	3,094
Gravity	9.0	100	308,000	11	34,222	3,080
Marine						
Seismic comp. air	1.9	3,386	946,600	1,782	498,210	279
Seismic implosive	0.2	146	73,000	730	365,000	500
Gravity	1.9	3,386	49,100	1,782	25,842	14
Airborne						
Magnetic	1.5	16,820	242,100	11,213	161,400	14
Far East						
Land						
Seismic dynamite	205.8	10,209	31,702,239	49	154,043	3,105
Seismic vibratory	3.5	294	735,000	84	210,000	2,500
Seismic other	40.0	2,043	4,642,923	51	116,073	2,272
Gravity	5.7	1,095	110,250	192	19,342	100
Marine						
Seismic comp. air	63.9	56,195	35,671,680	879	558,242	634
Seismic gas exploder	25.7	27,000	9,564,816	1,050	372,171	354
Gravity	12.7	10,914	200,240	859	15,766	18
Magnetic	0.3	1,133	28,283	11,310	282,830	25
Airborne						
Magnetic	5.4	43,027	744,235	7,967	137,821	17
R/S side-scan radar	9.0	61,350	1,231,250	6,816	136,805	20

*Total includes government and university activity.

acquisition costs per mile for land seismic rose 25 percent while marine costs rose only 6 percent.

The number of miles of seismic data recorded worldwide was up 8.6 percent on land and 13.5 percent in marine work. Group seismic surveys and speculation surveys were prevalent in 1979. As for energy sources, dynamite was used in 56 percent of the land seismic work, while Vibroseis accounted for 37 percent. In marine work, air guns captured 62 percent of that market, with gas exploders being the second favorite source.

A more comprehensive breakdown of statistical data by geographic area can be seen in Table 7. Table 8 shows seismic cost, line-miles, and crew-months by states in the U.S.A. Several states enjoyed increases resulting from seismic activity in both the western and eastern overthrusts. The Gulf Coast saw all of the increase in marine activity as both the East and West Coasts declined.

A 47-year history of seismic exploration in the U.S.A. is shown in Figure 5. This information is compiled by the SEG Business Office. Data for this graph are gathered monthly by telephone.

Tables 9 and 10 show petroleum seismic activity in Canada and Mexico. Canada shows approximately a 23 percent increase over 1978. Information on activity in Mexico is incomplete.

GRAVITY AND MAGNETIC SURVEYS

Table 11 shows worldwide expenditures for gravity and magnetic surveys. The 1979 data show a 26 percent increase in the use of these tools with most of the increase being in the petroleum area.

AIRBORNE SURVEYS

Reported data for airborne surveys showed a 45 percent increase (Table 12) over 1978 with most of the increase coming in the petroleum area. Magnetic surveys were the most popular airborne surveys. The large drop in radioactive surveys may not be real and could have resulted from confusion with the new questionnaire. Other tools can be compared in the Eastern and Western Hemispheres in Tables 13a and 13b.

LAND MINING

Expenditures for land mining activities are reported in Tables 14a and 14b. Mining activity was up in both hemispheres with the largest increases in expenditures occurring in Africa, Europe, and Canada. Some of the reported increase may be due to a better response from the mining community due to the introduction of the

(Text continued on p. 1579)

Table 8. U.S.A. petroleum seismic activity by area

State	Acquisition costs (US $)	Line-miles	Crew-months* Company	Crew-months* Contract	Total months
Land					
Undesignated	39,918,808	4,910	.0	90.7	90.7
Alaska	7,219,080	1,704	[illegible]	22.8	29.8
Alabama	6,146,454	653	27.7	22.5	50.2
Arkansas	4,999,977	1,448	17.[illegible]	18.[illegible]	35.3
Arizona	7,628,197	2,675	[illegible]	[illegible]	53.9
California	21,385,563	6,169	28	[illegible]	122.3
Colorado	9,581,[illegible]	2,[illegible]	6.0	[illegible]	58.2
Florida	2,9[illegible]	[illegible]	4	[illegible]	16.7
Georgia	[illegible]	47	[illegible]	[illegible]	8
Idaho	2,307,[illegible]	682	[illegible]	[illegible]	27.8
Illinois	[illegible]	25	[illegible]	[illegible]	10.0
Kansas	5,00[illegible]	1,240	[illegible]	[illegible]	85.3
Kentucky	[illegible]	13[illegible]	[illegible]	[illegible]	7.0
Louisiana	104,473,316	26,[illegible]	142.6	522.[illegible]	664.6
Maryland	39,[illegible]	14	.0	[illegible]	5
Michigan	12,724,094	4,020	5.0	106.[illegible]	111.1
Minnesota	745,822	570	.0	10.2	10.2
Missouri	220,900	61	.0	1.1	1.1
Mississippi	21,516,081	5,562	74.4	79.4	153.8
Montana	20,184,355	5,757	1.7	133.1	134.8
Nebraska	1,644,975	791	10.0	13.7	23.7
North Carolina	124,800	73	.0	1.1	1.1
North Dakota	44,636,708	12,301	18.0	250.5	268.5
New Mexico	12,220,859	3,361	11.1	73.8	84.9
Nevada	8,950,014	2,353	6.9	44.3	51.2
New York	180,000	60	.0	1.5	1.5
Ohio	228,000	88	.0	1.3	1.3
Oklahoma	39,740,532	8,927	46.0	194.4	240.4
Pennsylvania	3,924,976	1,659	.0	33.2	33.2
South Carolina	138,600	87	.0	.9	.9
South Dakota	648,000	211	2.0	1.0	3.0
Tennessee	2,654,576	1,162	1.0	25.1	26.1
Texas	161,101,107	48,028	203.9	1,008.7	1,212.6
Utah	16,808,268	3,222	31.4	74.3	105.7
Virginia	1,479,574	1,084	.0	16.6	16.6
Washington	576,000	104	.0	4.0	4.0
West Virginia	1,732,000	571	.0	14.9	14.9
Wyoming	53,016,663	11,941	108.1	257.9	366.0
Total Land	623,826,007	163,929	758.4	3,364.0	4,122.4
Marine					
East Coast	1,625,300	1,960	.0	3.9	3.9
Gulf Coast	64,325,239	164,752	66.8	178.9	245.7
West Coast	10,587,816	26,500	3.8	24.5	28.3
Total Marine	76,538,355	193,212	70.6	207.3	277.9
Total U.S.A.	700,364,362	357,141	829.0	3,571.3	4,400.3

*Total includes government and university activity.

Table 9. Petroleum seismic activity in Canada by area.

Province	Acquisition Costs (US $)	Line-miles	Crew-months Company	Crew-months Contract	Total months
Land					
Undesignated	27,034,210	7,855	.0	170.6	170.6
Alberta	127,516,181	37,214	85.0	345.9	430.9
British Columbia	39,149,306	8,364	13.0	77.0	90.0
Manitoba	1,550,000	900	1.0	4.0	5.0
Northwest Territories	1,445,000	786	.0	6.0	6.0
Saskatchewan	5,165,168	2,256	1.5	13.0	14.5
Total Land	201,859,865	57,375	100.5	616.5	717.0
Marine					
Undesignated	12,218,936	11,596	5.4	8.2	13.6
East Coast	2,011,219	2,996	1.2	10.2	11.4
Total Marine	14,230,155	14,592	6.6	18.4	25.0
Total Canada	216,090,020	71,967	107.1	634.9	742.0

Table 10. Petroleum seismic activity in Mexico by area.‡

Province	Acquisition Costs (US $)	Line-miles	Crew-months Company	Crew-months Contract	Total months
Land					
Various	9,925,530	3,532		74.6	74.6
Marine					
Various	18,460,400	35,536		34.7	34.7
Total Mexico	28,385,930	39,068		109.3	109.3

‡Incomplete report.

Table 11. Total worldwide expenditures on gravity and magnetic surveys in US $ (thousands).

Area	Petroleum	Minerals	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
International	990						978	1,968
U.S.A.	6,160	2,564	237	281	5		578	9,825
Canada	207	1,803	4				75	2,089
Mexico‡	1,400							1,400
So. America	872	48					103	1,023
Europe	1,170	1,267	113				25	2,575
Africa	2,875	1,921	16		50		70	4,932
Middle East	599	1,330						1,929
Far East	1,083	694	250			7,891		9,918
Australia								
New Zealand		501						501
Total	15,360	10,131	621	281	55	7,891	1,831	36,170

‡Incomplete report.

Table 12. Total worldwide expenditures on airborne surveys in US $ (thousands).

Area	Petroleum	Minerals	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
International	1,590							1,590
U.S.A.	5,609	5,053	206	156			420	11,444
Canada		10,122					295	10,417
Mexico‡	1,400							1,400
So. America	500	48						548
Europe	462	1,819	600					2,881
Africa	503	3,557						4,060
Middle East	242	2,100						2,342
Far East	1,975	1,688				300		3,963
Australia								
New Zealand		1,130						1,130
Total	12,283	25,520	806	156	0	300	715	39,780

‡Incomplete report.

Table 13a. Western Hemisphere airborne activity in US $ (thousands).

Survey Method	International Line-mile	International Cost	USA Line-mile	USA Cost	Canada Line-mile	Canada Cost	Mexico‡ Line-mile	Mexico‡ Cost	So. America Line-mile	So. America Cost
Gravity			*67,126	704						
Magnetic	40,000	990	308,249	6,210	70,248	1,501	58,500	1,400	14,220	548
Electromagnetic					21,000	225				
Combined EM Mag.			7,718	430	117,086	4,063				
VLF					4,500	160				
Input			30,450	1,066	122,900	3,978				
Radiometric (gamma ray)			33,863	1,235	28,830	488				
R-S side-scan radar	40,000	600	99,999	1,800						
Total	80,000	1,590	548,405	11,446	364,564	10,417	58,500	1,400	14,220	548

‡Incomplete report. *Was reported as gravity but may be magnetics.

Table 13b. Eastern Hemisphere airborne activity in U S $ (thousands).

Survey Method	Europe Line-mile	Cost	Africa Line-mile	Cost	Middle East Line-mile	Cost	Far East Line-mile	Cost	Australia Line-mile	Cost
Gravity			*100	7						
Magnetic	89,935	1,560	127,417	2,109	50,820	1,492	101,027	1,738	30,000	450
Combined EM/ Mag.	2,850	190	9,063	55	4,600	350				
Input	5,000	500	25,000	1,760	7,200	500			11,000	680
Radiometric (gamma ray)	2,400	31	8,138	129						
Kemot-sens. thrm. infr	250	600								
R-S side-scan radar							115,150	2,225		
Total	100,435	2,881	169,718	4,061	62,620	2,342	216,177	3,963	41,000	1,130

*Was reported as gravity but may be magnetics.

Table 14a. Western Hemisphere land mining activity in U S $ (thousands).

Survey method	U.S.A. Line-mile	Cost	Canada Line-mile	Cost	Mexico† Line-mile	Cost	So. America Line-mile	Cost
Seismic dynamite			2					
Seismic vibratory	97	152	72	324				
Seismic dynamite (refraction)	51	59	2	12				
Seismic gas exploder (refraction)	7	25	2	2				
Seismic other	82	122						
Gravity	355	50	591	215				
Magnetic	1,398	191	971	86				
Resistivity	946	159	829	260				
Self-potential	130	20						
Electromagnetic	422	78	1,599	515				
Combined EM/Mag.	456	146	1,748	631	200	50		
VLF	15	-	254	31				
Almag			-	-				
Induced polarization	484	335	1,434	960	300	50		
Radiometric (gamma ray)	4,509	32	1,070	17				
Radiometric (alpha track)	390	-	316	54				
Magnetotelluric	75	420						
Other	126	345						
Total	9,602	2,165	8,894	3,116	500	100		

‡Incomplete report.

Table 14b. Eastern Hemisphere land mining activity in U S $ (thousands).

Survey Method	Europe Line-mile	Cost	Africa Line-mile	Cost	Middle East Line-mile	Cost	Far East Line-mile	Cost	Australia Line-mile	Cost
Seismic dynamite	660	3,872								
Seismic vibratory	129	505								
Seismic other	430	930	1	12						
Gravity	1,500	150	379	97					861	51
Magnetic	42	20	1,571	187	150	80				
Resistivity	836	330	1,174	317	695	221			1,074	154
Self-potential	16	10	12	1						
Electromagnetic	154	79	1,012	158					177	26
Combined EM/ Mag.	26	20	6	14						
VLF	25	10								
Induced polarization	17	30	600	279					1,119	284
Earth current			284	14						
Radiometric			4,438	57						
Radiometric (gamma ray)			395	16						
Radiometric (alpha track)	80	15	20	4						
Magnetotelluric			6	11						
Other			449	18						
Total	4,015	6,062	10,354	1,194	845	301			3,231	517

HISTORY OF SEISMIC EXPLORATION ACTIVITY IN THE UNITED STATES

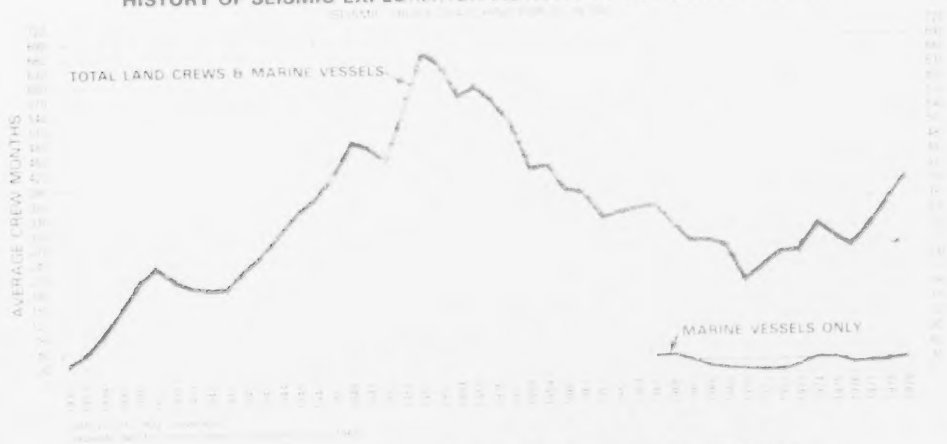

FIG. 5. History of seismic exploration activity in the U.S., 1932-1979.

Table 15. Worldwide average unit costs by survey objective, type, and method.

Survey objective, type and method	Crew months or (man-months) total*	Line-miles or (square-mile coverage)	Acquisition costs (U.S.$)	Average mile/month or (feet/month)	Average cost/month or (cost/man-month)	Average cost/mile or (cost/ft)
Petroleum						
Land						
Seismic dynamite	4,137.2	185,448	788,631,577	44	190,619	4,252
Seismic dynamite (refraction)	3.0	180	97,088	60	32,333	538
Seismic comp. air	92.9	9,343	15,212,064	100	163,746	1,628
Seismic electrical	1.0	84	210,000	84	210,000	2,500
Seismic gas exploder	71.8	3,056	7,987,236	42	111,242	2,613
Seismic implosive	1.0	17	178,703	17	178,703	10,511
Seismic weight drop	106.4	5,598	10,414,196	52	97,877	1,860
Seismic solid chem.	42.7	1,249	7,551,880	29	176,859	6,046
Seismic vibrators	2,308.3	124,466	367,714,373	53	159,300	2,954
Seismic other	88.8	4,209	10,301,162	47	116,004	2,447
Gravity	185.5	46,845	5,819,224	252	31,370	124
Magnetic	5.7	265	93,865	46	16,467	354
Resistivity	0.5	10	20,000	20	40,000	2,000
Electromagnetic	16.5	1,124	460,560	68	27,912	409
Induced polarization	17.0	1,700	425,000	100	25,000	250
Radiometric	6.0	1,300	860,000	216	143,333	661
Magnetotelluric	33.0	381	2,818,000	11	85,393	7,396
Other	4.0	79	309,000	19	77,250	3,911
Marine						
Seismic comp. air	440.8	348,907	182,543,575	791	414,118	523
Seismic comp. air (refraction)	0.5	73	216,861	146	433,722	2,970
Seismic electrical	4.0	2,400	1,072,000	600	268,000	446
Seismic gas exploder	177.3	165,828	55,646,454	935	313,854	335
Seismic implosive	40.3	32,017	16,008,500	794	397,233	500
Seismic solid chem.	16.5	16,500	4,800,000	1,000	290,909	290
Gravity	28.6	37,010	729,465	1,294	25,505	19
Magnetic	0.5	2,626	65,657	5,252	131,314	25

*Total includes government and university activity.

Table 15. Worldwide average unit costs by survey objective, type, and method (cont.).

Survey objective, type and method	Crew months or (man months) (total)*	Line-miles or (logged footage)	Acquisition costs (US $)	Average mile/month or (feet/month)	Average cost/month or (cost/man month)	Average cost/mile or (cost/ft)
Petroleum (cont.)						
Airborne						
Magnetic	67.6	390,238	8,652,203	5,772	127,991	22
R-S side-scan radar	16.5	201,349	3,631,250	12,202	220,075	18
Drill hole						
Sonic/vel. logging	30.5	**	553,937	**	17,985	**
Sonic/vel. logging	(35.8)	(93,000)	187,878	(2,500)	(5,247)	(2.02)
Minerals						
Land						
Seismic dynamite	35.4	662	3,873,416	18	109,418	5,851
Seismic dynamite (refraction)	7.1	151	149,700	21	21,085	991
Seismic dynamite (refraction)	(2.0)	2	12,520	(1)	(6,260)	6,260
Seismic gas exploder (refraction)	1.0	7	25,000	7	25,000	3,571
Seismic solid chem. (refraction)	(9.0)	59	16,300	(6)	(1,811)	276
Seismic vibratory	12.2	298	981,940	24	80,486	3,295
Seismic other	12.8	513	1,065,000	40	83,203	2,076
Seismic other (refraction)	1.0	7	4,500	7	4,500	642
Seismic other (refraction)	(0.3)	1	2,000	(3)	(6,666)	2,000
Gravity	50.4	3,232	465,530	64	9,235	144
Gravity	(24.0)	454	98,450	(18)	(4,102)	216
Magnetic	46.2	2,690	406,865	58	8,806	151
Magnetic	(56.4)	1,442	158,501	(25)	(2,810)	109
Resistivity	95.0	4,950	1,301,200	52	13,700	263
Resistivity	(114.5)	604	142,456	(5)	(1,244)	235
Self-potential	1.0	130	20,000	130	20,000	154
Self-potential	(10.5)	28	11,200	(2)	(1,066)	400
Electromagnetic	46.3	2,728	652,226	59	14,087	239
Electromagnetic	(63.2)	636	206,098	(10)	(3,261)	324
Combined EM/mag.	44.8	2,159	694,070	48	15,493	321
Combined EM/mag.	(56.0)	277	167,661	(4)	(2,993)	605
VLF	2.5	143	26,200	57	10,480	183
VLF	(13.8)	151	19,782	(10)	(1,433)	131
Afmag	0.5	5	5,000	10	10,000	1,000
Induced polarization	114.1	3,503	1,622,500	31	14,220	463
Induced polarization	(135.5)	451	317,174	(3)	(2,340)	703
Earth current	6.0	284	14,500	47	2,416	51
Radiometric	7.0	4,438	57,694	634	8,242	13
Radiometric (gamma ray)	34.9	3,229	22,772	93	652	7
Radiometric (gamma ray)	(42.5)	2,745	44,220	(64)	(1,040)	16
Radiometric (alpha track)	2.2	100	19,500	45	8,864	195
Radiometric (alpha track)	(25.8)	706	59,940	(27)	(2,323)	84
Magnetotelluric	5.8	81	431,000	13	74,310	5,320
Other	9.7	126	345,530	13	35,622	2,742
Other	(7.5)	449	18,400	(59)	(2,453)	40
Marine						
Seismic electrical	0.1	20	4,220	200	42,200	211
Airborne						
Gravity	13.3	52,759	555,000	3,966	41,729	10
Magnetic	65.1	369,848	7,156,525	5,681	109,931	19
Magnetic	(54.0)	44,174	1,266,604	(818)	(23,455)	28
Electromagnetic	6.0	21,000	225,000	3,500	37,500	10
Combined EM/mag.	51.8	138,429	4,940,010	2,672	95,367	36
Combined EM/mag.	(16.0)	2,888	148,954	(180)	(9,309)	51
VLF	1.0	4,500	160,000	4,500	160,000	35

*Total includes government and university activity. **Not applicable.

Table 15. Worldwide average unit costs by survey objective, type, and method (cont.).

Survey objective, type, and method	Crew months or (man months) total*	Line-miles or (logged footage)	Acquisition costs (US $)	Average mile/month or (feet/month)	Average cost/month or (cost/man month)	Average cost/mile or (cost/ft)
Minerals (cont.)						
Input	42.8	201,550	8,485,000	4,654	195,958	42
Input	5.6	6,738	111,600	4,211	69,750	16
Radiometric	11.7	51,372	1,422,450	4,391	121,577	28
Radiometric, seismic (sp)	(0.3)	1,121	56,050	(186)	(9,341)	50
Radiometric (gamma)	8.0	53,800	993,750	6,725	124,218	18
K-S side-scan radar						
Drill hole	2.0	**	24,000	**	12,000	**
Magnetic	3.0	**	70,000	**	23,333	**
Resistivity	20.5	(823,400)	1,642,038	(40,000)	80,099	(1.99)
Resistivity	(4.0)	(20,000)	9,000	(5,000)	(2,250)	(.45)
Resistivity	(0.4)	(5,900)	4,100	(14,700)	(10,250)	(.69)
Sonic vel. logging	1.1	**	9,200	**	8,363	**
Electromagnetic	1.5	(3,000)	6,500	(2,000)	4,333	(2.16)
Electromagnetic	8.7	**	71,000	**	8,161	**
Induced polarization	(17.0)	(32,000)	136,850	(1,800)	(8,050)	(4.27)
Induced polarization	214.0	**	1,800,000	**	8,411	**
Radiometric	59.0	(512,000)	269,400	(8,600)	4,566	(.52)
Radiometric	(14.8)	(217,300)	74,739	(14,600)	(5,049)	(.34)
Radiometric	46.0	**	1,244,839	**	27,061	**
VLF	(8.0)	(95,000)	30,000	(11,800)	(3,750)	(.31)
Other						
Engineering						
Land	8.0	63	398,425	7	49,803	5,039
Seismic dynamite	(4.0)	13	71,088	(3)	(17,750)	5,461
Seismic dynamite (refraction)	33.7	653	1,366,540	19	40,550	2,086
Seismic dynamite (refraction)	(19.5)	186	843,275	(1)	(7,056)	4,533
Seismic comp. air (refraction)	0.1	1	10,000	10	100,000	10,000
Seismic electrical	(1.7)	5	17,066	(2)	(10,000)	3,400
Seismic gas exploder	0.3	2	1,500	6	5,000	750
Seismic weight drop	(2.0)	3	3,500	(1)	(1,750)	1,166
Seismic weight drop (refraction)	2.5	14	102,705	6	41,082	7,336
Seismic weight drop (refraction)	(2.7)	7	22,325	(2)	(8,268)	3,189
Seismic other (refraction)	7.5	116	293,500	15	39,133	2,530
Seismic other (refraction)	(1.0)	5	10,000	(5)	(10,000)	2,000
Gravity	7.0	1,080	113,500	143	16,214	114
Gravity	(4.6)	27	16,125	(5)	(3,505)	597
Magnetic	3.0	300	250,000	100	83,333	833
Magnetic	(0.7)	3	5,250	(4)	(7,500)	1,750
Resistivity	26.5	664	484,400	25	18,279	730
Resistivity	(21.8)	565	213,200	(25)	(9,779)	377
Self-potential	1.0	75	1,500	75	1,500	20
Electromagnetic	(16.4)	190	216,000	(12)	(13,171)	1,137
VLF	(9.0)	88	25,000	(10)	(2,777)	284
Induced polarization	2.0	10	50,000	5	25,000	5,000
Remote-sens. other	12.0	500	15,000	41	1,250	30
Other	(67.8)	380	1,911,600	(6)	(28,195)	5,031
Marine	64.9	16,935	5,346,124	261	82,375	316
Seismic electrical	(45.4)	2,633	750,000	(57)	(16,519)	284
Seismic electrical	29.5	14,645	5,324,700	496	180,498	363
Seismic gas exploder	5.0	1,100	900,000	220	170,000	773
Seismic other	(2.0)	400	50,000	(200)	(25,000)	125
Seismic other	0.5	5	85,000	10	170,000	17,000
Seismic other (refraction)						

*Total includes government and university activity. **Not applicable.

Table 15. Worldwide average unit cost, by survey objective, type, and method (cont.).

Survey objective, type and method	Crew months or (man months) total*	Line-mile (square foot)	Dollars per (square mile)	Average mile/month or (feet/month)	Average cost/month or (cost/man month)	Average cost/mile or (cost/ft)
Engineering (cont.)						
Airborne						
Magnetic	3.5	(6,000)	206,400	4,585	58,971	12
Remot-sns. thrm. infra	7.0	(20)	693,000	35	85,714	2,400
Drill hole						
Magnetic	(1.0)	(15,000)	15,000	(15,000)	(30,000)	(2.00)
Resistivity	(4.5)	(10,000)	22,000	(2,200)	(4,888)	(2.20)
Self-potential	0.5	(10,000)	2,000	(20,000)	4,000	(.20)
Sonic/vel. logging	1.0	**	22,000	**	22,000	**
Sonic/vel. logging	3.0	(22,000)	90,000	(10,000)	30,000	(2.81)
Sonic/vel. logging	(50.7)	(78,000)	277,650	(1,538)	(5,474)	(3.55)
Electromagnetic	(1.0)	(4,000)	8,500	(4,200)	(8,500)	(2.02)
Electromagnetic	0.5	(10,000)	2,000	(20,000)	4,000	(.20)
VLF	0.5	(10,000)	2,000	(20,000)	4,000	(.20)
Other	30.0	**	2,000,000	**	66,666	**
Other	(6.5)	(24,500)	43,000	(3,700)	(6,615)	(1.75)
Geothermal						
Land						
Seismic dynamite	0.3		6,000	3	20,000	6,000
Seismic dynamite (refraction)	2.3	34	170,000	14	73,913	5,000
Seismic gas exploder	0.3	2	5,000	3	16,666	5,000
Seismic vibratory	1.4	54	196,200	38	140,142	3,633
Gravity	7.0	747	110,000	107	15,714	147
Gravity	(4.0)	200	15,500	(50)	(3,875)	77
Resistivity	6.2	56	51,080	11	8,107	681
Self-potential	2.2	1,325	182,693	172	23,726	137
Electromagnetic	2.0	72	51,000	36	25,500	708
Radiometric (gamma ray)	0.5	20	8,000	40	16,000	400
Magnetotelluric	17.0	240	1,453,000	14	85,470	6,054
Other	11.4	275	407,600	24	35,754	1,482
Airborne						
Gravity	3.5	14,467	156,000	4,133	44,571	10
Drill hole						
Resistivity	0.5	(5,000)	5,000	(10,000)	10,000	(1.00)
Temp. gradient	7.5	**	491,000	**	37,500	**
Temp. gradient	23.3	(123,300)	573,000	(5,200)	24,592	(4.64)
Temp. gradient	(5.0)	(40,000)	40,000	(8,000)	(8,000)	(1.00)
Other	3.0	**	1,000,000	**	333,333	**
Groundwater						
Land						
Seismic dynamite	0.3	20	2,500	66	8,333	125
Seismic dynamite (refraction)	14.0	250	111,120	18	7,937	445
Seismic dynamite (refraction)	(12.0)	60	12,000	(5)	(10,000)	2,000
Seismic solid chem. (refraction)	0.1	1	3,000	10	30,000	3,000
Seismic vibratory	2.0	32	105,000	16	52,500	3,281
Gravity	2.0	72	25,000	36	12,500	347
Magnetic	1.3	200	30,000	153	23,076	150
Resistivity	193.6	4,825	4,393,879	25	22,695	911
Resistivity	(6.5)	114	94,048	(17)	(14,468)	824
Resistivity	0.5	30	15,000	60	30,000	500
Combined EM/mag.	0.4	1	7,000	2	17,500	7,000
Other						
Drill hole	5.7	**	48,088	**	8,436	**
Resistivity	31.0	(149,100)	266,000	(4,800)	8,580	(1.78)
Resistivity	(12.0)	(141,800)	22,000	(11,800)	(1,833)	(.15)
Resistivity						

*Total includes government and university activity. **Not applicable.

Table 15. Worldwide average unit costs by survey objective, type, and method (cont.).

Survey objective, type and method	Crew months or (man months) total*	Line-miles or (logged footage)	Acquisition costs (US $)	Average mile/month or (feet/ month)	Average cost/ month or (cost/ man month)	Average cost/mile or (cost/ ft)
Ground water, Drill hole (cont.)						
Self-potential	1.0	(2,500)	5,000	(2,500)	5,000	(2.00)
Sonic/vel. logging	1.0	**	15,000	**	15,000	**
Input	(2.0)	(16,000)	12,000	(8,000)	(6,000)	(.75)
Radiometric (gamma ray)	1.0	**	6,000	**	6,000	**
Radiometric (gamma ray)	1.1	(3,100)	6,350	(2,800)	5,772	(2.04)
Radiometric (gamma ray)	(3.5)	(31,500)	103,000	(9,000)	(29,428)	(3.26)
Temp. gradient	0.5	(1,500)	3,000	(3,000)	6,000	(2.00)
Oceanography						
Marine						
Seismic dynamite	7.2	8,881	2,868,538	1,233	398,408	322
Seismic comp. air	9.7	32,716	2,969,550	3,372	306,139	90
Seismic comp. air (refraction)	0.3	402	132,200	1,340	440,666	328
Seismic electrical	41.9	34,472	9,617,330	822	229,530	278
Seismic implosive	3.0	3,000	300,000	1,000	100,000	100
Magnetic	29.7	25,305	7,591,500	852	255,606	300
Airborne						
Magnetic	2.0	30,000	30,000	15,000	150,000	10
Research						
Land						
Seismic dynamite	2.0	115	210,225	57	105,112	1,828
Seismic dynamite (refraction)	(9.4)	16	70,860	(1)	(7,538)	4,428
Seismic comp. air	(2.0)	2	10,000	(1)	(5,000)	5,000
Seismic weight drop	3.0	75	2,500	25	833	33
Seismic solid chem.	1.5	60	34,500	40	23,000	575
Seismic vibratory	11.0	385	1,757,770	35	159,797	4,565
Seismic other	(1.0)	2	6,000	(2)	(6,000)	3,000
Gravity	29.8	16,751	205,214	562	6,886	12
Gravity	(18.0)	651	74,500	(36)	(4,138)	114
Magnetic	1.1	60	28,000	55	25,455	467
Magnetic	(10.2)	11	24,800	(1)	(2,431)	2,254
Resistivity	4.0	160	35,000	40	8,750	219
Resistivity	(11.4)	104	62,600	(9)	(5,491)	601
Electromagnetic	(2.0)	12	4,000	(6)	(2,000)	333
Induced polarization	9.0	80	135,000	8	15,000	1,687
Radiometric (gamma ray)	(7.0)	80	49,000	(11)	(7,000)	612
Other	(4.0)	100	45,700	(25)	(11,425)	457
Marine						
Seismic dynamite	(4.0)	100	40,000	(25)	(10,000)	400
Seismic comp. air	6.6	26,343	1,183,849	3,990	177,855	45
Seismic comp. air	(3.0)	20	10,000	(6)	(3,333)	500
Seismic comp. air (refraction)	(6.0)	115	100,000	(19)	(16,666)	869
Seismic solid chem.	0.1	200	11,929	2,000	119,290	59
Gravity	(1.0)	100	5,000	(100)	(5,000)	50
Magnetic	8.2	40,385	1,073,722	4,925	130,330	26
Magnetic	(1.0)	100	5,000	(100)	(5,000)	50
Airborne						
Magnetic	3.0	15,300	220,500	5,100	73,500	14
Magnetic	(5.5)	25,806	199,500	(4,692)	(36,272)	7
Electromagnetic	3.1	14,000	295,000	4,516	95,161	21
Drill hole						
Resistivity	(6.0)	(3,000)	5,000	(500)	(833)	(1.66)
Sonic/vel. logging	(9.0)	(11,000)	60,000	(1,222)	(6,666)	(5.45)

*Total includes government and university activity. **Not applicable.

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new alternate questionnaire which was designed to facilitate reporting nonpetroleum activity.

ENGINEERING, GROUNDWATER, GEOTHERMAL, OCEANOGRAPHY, AND RESEARCH

Worldwide average unit costs for these activities can be found in Table 3. Distribution of expenditures by survey type and geographic area can be found in Tables 1 and 2. We believe that these activities are still underreported. In the geothermal area, for instance, we suspect that perhaps as little as one-third of the total activity was reported. The new "alternate form" questionnaire has helped improve reporting, but it does not yet meet the needs of these segments of the geophysical industry. Further improvements will be made to the alternate questionnaire next year to make the form more applicable to these areas.

SUMMARY

In general, the data reported here are believed to be more complete than in 1978 due to better response to the questionnaire. An effort was made to encourage geophysical contractors to report all expenses incurred in a geophysical survey, whether they are paid by the contractor or the client. Further attempts are being made to encourage complete reporting. As companies and contractors become convinced that the confidential and financially sensitive data requested on the questionnaire are being properly safeguarded and protected, we believe that more complete data will become available.

ACKNOWLEDGMENTS

This report was made possible through the contributions of statistical data by companies, contractors, government agencies, and universities. For many of these organizations, compilation of these data was a long and tedious task. The Geophysical Activity Committee expresses sincere appreciation to all of those individuals who were instrumental in preparing and submitting their activity questionnaires. The committee welcomes comments and suggestions on ways to improve the report.

A special vote of thanks goes to Russell J. Senti who did most of the work on this report and Jerry Henry and Virginia Corney of the SEG Business Office who handled the voluminous chores of mailing, receiving, coding, and checking the questionnaires.

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